MATERIAL TESTING LABORATORY

A MANUAL OF EXPERIMENTS – PART 1

1. Tension Test on Mild Steel rods
2. Shear Test on Steel rods
3. Torsion Test on Mild steel rods
4. Torsion Test on Steel wires
5. Test on Close – coiled spring
6. Test on Open – coiled spring
7. Bending test on wooden beams
8. Verification of Clarke-Maxwell Reciprocal Theorem

KIRAN S. R.

Lecturer

Department of Civil Engineering

Central Polytechnic College Trivandrum

Date:

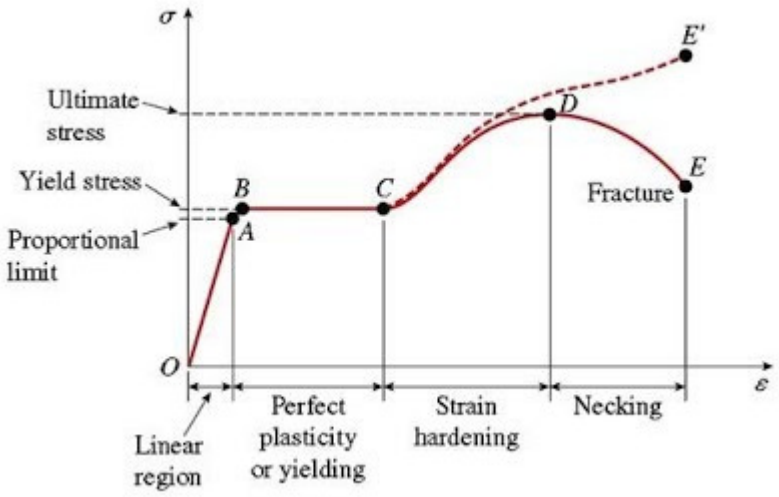
Experiment No. 01

TENSION TEST ON MILD STEEL RODS

AIM: To conduct a tensile test on a mild steel specimen and determine the Yield stress, Ultimate stress, Nominal Breaking stress, Actual Breaking stress, Percentage elongation and Percentage reduction in area.

APPARATUS: Universal Testing Machine (UTM), Mild steel specimens, Scale, Punching tool, Vernier Calipers

THEORY: In engineering, tension test is widely used to provide basic design information on the strength of the materials. Here, a specimen is subjected to a continually increasing uniaxial tensile force while simultaneous observations are made of the elongation of the specimen. A stress-strain curve is plotted from the load-elongation measurements.



PROCEDURE:

1. Clean the given mild steel rod with sandpaper. Measure the diameter of the rod at 3 different points and compute the mean diameter.
2. Calculate the gauge length and mark the end-to-end distance on the rod at this gauge length by punch marks.
3. Assuming suitable permissible tensile stress and factor of safety, calculate the maximum expected load on the specimen and select the range of the UTM. Also prime the machine.
4. Fix the test specimen tightly between the chucks of the upper and middle crosshead of the machine.
5. Now, turn the load control knob of UTM and start loading the specimen gradually.
6. The load at which the load pointer becomes stationary for a while is called the yield point.
7. Now, the load increases further and reaches a maximum known as ultimate load.
8. After this, the load pointer returns leaving the dummy at the ultimate load and the specimen breaks. This is the breaking load.

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum

9. Note the distance between the punch marks near the breaking point and also the neck diameter.

OBSERVATIONS:

Least count of vernier =

Sl. No.	MSR (mm)	VSR (div)	Actual Dia = MSR+ (VSR x Least count)
1			
2			
3			

Mean Diameter of bar, d =

Original Cross sectional area A_o=

Gauge Length Lo = $5.65\sqrt{Ao}$ =

Allowable tensile stress, f_{allow} =

Factor of safety = 4

Approximate ultimate tensile stress f = f_{allow} x FOS =

Maximum expected load = f x Ao =

Range selected =

Yield point =

Ultimate load =

Breaking load =

Neck diameter =

Final gauge length, Lu =

Neck area =

% elongation =

% reduction in area =

RESULT:

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum

Date:

Experiment No. 02

SHEAR TEST ON MILD STEEL RODS

AIM: To determine the shear strength of the given material

APPARATUS: Universal Testing Machine (UTM), Mild steel specimens, Test Rig, Vernier Calipers

THEORY:

A cylindrical specimen is subject to double shear using a suitable test rig under compressive load and the maximum load (F) at fracture is recorded. Since two planes of shear failure is involved in the specimen of cross-sectional area A , the shear strength is computed as equal to F/2A.

PROCEDURE:

1. Clean the given mild steel rod with sandpaper. Measure the diameter of the rod at 3 different points and compute the mean diameter.
2. Assuming suitable allowable shear stress and factor of safety, calculate the expected failure load on the specimen and select the range of the UTM. Also prime the machine.
3. Fix the test specimen in the testing rig, place it between the middle & lower cross head and load it at uniform rate till failure occurs.
4. Note the load at which failure occurs.

OBSERVATIONS:

Least count of vernier =

Sl. No.	**MSR (mm)**	**VSR (div)**	**Actual Dia = MSR+ (VSR x Least count)**
1			
2			
3			

Mean Diameter of bar, d =

Original Cross sectional area A_o=

Allowable shear stress, f_{allow} =

Factor of safety = 4

Approximate ultimate shear strength f = f_{allow} x FOS =

Maximum expected load = f x $2A_o$ =

Range selected =

Breaking load F =

Shear strength = $F/2A_o$ =

RESULT:

Date:

Experiment No. 03

TORSION TEST ON MILD STEEL RODS

AIM: To determine the modulus of rigidity of the given material

APPARATUS: Torsion meter, Mild steel specimens, Scale, Vernier Calipers

THEORY:

Modulus of rigidity of a material and shear stress for certain torque is obtained from the following formula:

$$\frac{T}{J} = \frac{\tau_{max}}{R} = \frac{N\theta}{L}$$

where, T = Torque acting on mild steel specimen,

J =Polar moment of inertia,

τ_{max} = Maximum shear stress,

N = Modulus of rigidity,

θ = Angle of twist in radians and

L = Length of mild steel specimen.

PROCEDURE:

i. The diameter of rod is measured using screw gauge or vernier calipers .
ii. The specimen is tightly fixed in the vice between the jaws.
iii. The distance between the gauge is measured using steel rule
iv. The graduated scale is adjusted to zero .
v. Apply 1 kg load and corresponding twist is noted. Loading is continued gradually up to 6kg and corresponding twist is noted.
vi. Unloading is continued and corresponding twist is noted.
vii. Graph is plotted with torque along Y axis and angle of twist(Θ in radians) along X axis

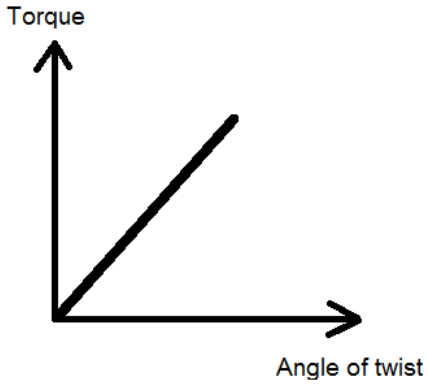
OBSERVATIONS:

Length of specimen =

Diameter of specimen =

Angle of twist							
Load							
Torque							

To find the ratio Torque-Angle of twist, plot the graph Torque vs. Angle of twist and measure slope.



From graph, $\frac{T}{\theta}$ =

Polar moment of inertia J = $\pi d^4/32$ =

Modulus of rigidity N = $TL/J\Theta$ =

Maximum torque applied T_1 =

Maximum shear stress = $T_1 r/J$ =

RESULT:

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum

Date:

Experiment No. 04

TORSION TEST ON MILD STEEL WIRES

AIM: To determine the modulus of rigidity of the given wire

APPARATUS: Torsion pendulum disc & ring, stopwatch, screwgauge, scale

THEORY:

This method is based on oscillation. A disc suspended by an elastic wire, when twisted slightly in one direction, begins to oscillate about its equilibrium position. The period of oscillation for torsion pendulum is given by,

$$T = 2\pi\sqrt{\frac{I\,l}{NJ}} \quad \text{where}$$

N = Modulus of Rigidity of the wire,

J = Polar moment of Inertia of the wire

l = length of the wire and

I = Mass moment of Inertia of the disc about the vertical axis.

The main part of the experiment is measurement of the period of oscillation with and without the ring for a particular length of the wire.

Let I_1 = mass moment of inertia of the disc about the vertical axis through the centre of the disc

I_2 = mass moment of inertia of disc about the vertical axis through the centre of the disc with ring

T_1 = time for oscillation of the pendulum without ring

T_2 = time for oscillation of the pendulum with ring

So, $T_1 = 2\pi\sqrt{\frac{I_1\,l}{NJ}}$ and $T_2 = 2\pi\sqrt{\frac{I_2\,l}{NJ}}$

PROCEDURE:

1. Find diameter of wire using screw gauge
2. Suspend the disc by the wire. Measure the length of the wire from the point of oscillation.
3. Apply twist to the disc and allow it to oscillate. When oscillations become steady, start the stopwatch and note the time interval for 20 oscillation (T1).

4. Place the ring on the disc and find the time interval for 20 oscillations (T2).
5. Repeat the experiment with 3 different lengths of pendulum

OBSERVATIONS:

Diameter of wire, d =

Mass of disc =

Mass of ring =

Radius of disc =

Outer radius of ring =

Inner radius of ring =

Polar moment of inertia $J = \pi d^4/32$ =

We know

$$I_{disk} = \frac{1}{2} M_{disk} R^2 .$$

$$I_{ring} = \frac{1}{2} M_{ring} \left(R_1^2 + R_2^2 \right)$$

I_2 = $I_{disc} + I_{ring}$ =

I_1 = I_{disc} =

$I_2 - I_1$ =

Modulus of rigidity N is computed as

$$N = \frac{4\pi^2 L (I_2 - I_1)}{J (T_2^2 - T_1^2)}$$

Sl No	l mm	t_1 sec			t_2 sec			T_1 sec	T_2 sec	N	Avg. N
		1	2	Avg.	1	2	Avg.			N/mm^2	
1											
2											
3											

RESULT:

Date:

Experiment No. 05

TEST ON CLOSE – COILED SPRING

AIM: To determine modulus of rigidity of the spring material

APPARATUS: spring testing machine, screw gauge, vernier caliper

THEORY:

$$\text{Deformation of the spring, } \delta = \frac{64\ WR^3n}{Nd^4} \text{ mm}$$

$$\text{Stiffness of the spring} = \frac{W}{\delta} \text{ N/mm}$$

Where, W – Load from graph, N

R – Mean radius of the coil, mm

n – Number of turns of the spring

N -Rigidity modulus of the spring, N/mm^2

d – Diameter of spring, mm

δ - Deformation, mm

$$\text{Modulus of elasticity, } E = 2N\left[1 + \frac{1}{m}\right]$$

where, $\frac{1}{m}$ =Poisons ratio.

PROCEDURE:

i. Measure the outer diameter of coil(D)and diameter of coil wire (d),using vernier calipers.

ii. Number of turns of coil is counted.

iii. The given coil is fixed to the machine and the hook is adjusted so that the vernier and main scale of scale reads zero.

iv. A load of 1 kg is applied and corresponding deflection is noted

v. Loading is continued upto 7 kg and corresponding deflections are noted

vi. The loads are unloaded and corresponding deflections are noted

vii. The average deflection during loading and unloading is calculated

viii. Graph is plotted with load(W)on Y axis and deflection (δ) on X axis.

OBSERVATIONS:

Least Count of Vernier = _____ mm

Sl. No.	MSR, mm	VSR	Diameter = (MSR+VSRxLC), mm
1 2 3			

Average dia. of the wire, d = _____ mm

Least Count of Vernier = _____ mm

Sl. No.	MSR, mm	VSR	Diameter = (MSR+VSRxLC), mm
1 2 3			

Average outer dia. of the coil, D = _____ mm

Mean radius of the coil, R $= \frac{D - d}{2}$

= mm

Number of turns of the coil =

Sl. No.	Load W, N	Deflected scale reading, cm		Deflection of the spring, cm		Mean deflection δ, mm
		Loading	Unloading	Loading	Unloading	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Calculations

From graph, $\frac{W}{\delta}$ = _____ N/mm

$\delta = \frac{64\ WR^3n}{Nd^4}$;

ie, Modulus of rigidity, $N = \frac{64\ WR^3n}{\delta d^4}$ = = _____ N/mm^2

Modulus of elasticity, $E = 2N\left[1 + \frac{1}{m}\right]$ = =_____ N/mm^2

RESULT:

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum

Date:

Experiment No. 06

TEST ON OPEN – COILED SPRING

AIM: To determine modulus of rigidity of the spring material

APPARATUS: spring testing machine, screw gauge, vernier caliper

THEORY:

$$\text{Deformation of the spring, } \delta = \frac{64\ WR^3 n\ Sec\alpha}{d^4}\left[\frac{Cos^2\alpha}{N}+\frac{2Sin^2\alpha}{E}\right]$$

$$\text{But, Modulus of elasticity, } E = 2N\left[1+\frac{1}{m}\right]$$

where, $\frac{1}{m}$ =Poisons ratio

$$\text{Deformation of the spring, } \delta = \frac{64\ WR^3 n\ Sec\alpha}{d^4}\left[\frac{Cos^2\alpha}{N}+\frac{2Sin^2\alpha}{2N\left(1+\frac{1}{m}\right)}\right]$$

$$\text{Stiffness of the spring} = \frac{W}{\delta}$$

where,

W - Load from graph, (N)

R – Mean radius of the coil, (mm)

n – Number of turns of the spring

N – Rigidity modulus of the spring, (N / mm^2)

d – Diameter of spring, (mm)

δ – Deformation, (mm)

α – angle of helix

$$\text{Angle of helix, } \tan\alpha = \frac{\text{Pitch}}{\text{Circumference of coil}} = \frac{p}{2\pi R}$$

PROCEDURE:

i. Measure the outer diameter of coil(D)and diameter of coil wire (d),using vernier calipers.
ii. Number of turns of coil and length of coil is counted.
iii. The given coil is fixed to the machine and the hook is adjusted so that the vernier and main scale of scale reads zero
iv. A load of 1 kg is applied and corresponding deflection is noted
v. Loading is continued upto 7 kg and corresponding deflections are noted
vi. The loads are unloaded and corresponding deflections are noted
vii. The average deflection during loading and unloading is calculated
viii. Graph is plotted with load(W)on Y axis and deflection (δ) on X axis.

OBSERVATIONS:

Least Count of Vernier = _____ mm

Sl. No.	MSR, mm	VSR	Diameter = d (MSR+VSRxLC),mm
1 2 3			

Sl. No.	MSR, mm	VSR	Diameter = D (MSR+VSRxLC),mm
1 2 3			

Average dia. of the wire, d = _____ mm

Average outer dia. of the coil, D = _____ mm

Mean radius of the coil, R = $\frac{D - d}{2}$ = = mm

Number of turns of the coil =

Length of the coil, L =

Pitch, $p = \frac{\text{Length of coil (L)}}{\text{Number of Turns of coil - 1}}$ = = mm

Angle of helix, $\tan\alpha = \frac{\text{Pitch}}{\text{Circumference of coil}} = \frac{p}{2\pi R}$ = =

Sl. No.	Load W, N	Deflected scale reading, cm		Deflection of the spring, cm		Mean deflection δ, mm
		Loading	Unloading	Loading	Unloading	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Calculations

From graph, $\frac{W}{\delta}$ = _____ N/mm

Deformation of the spring, $\delta = \frac{64\ WR^3 n\ Sec\alpha}{d^4}\left[\frac{Cos^2\alpha}{N}+\frac{2Sin^2\alpha}{2N\left(1+\frac{1}{m}\right)}\right]$

ie, Modulus of rigidity, N =

RESULT:

Date:

Experiment No. 07

BENDING TEST ON WOODEN BEAM

AIM: To determine the modulus of elasticity of wood by conducting bending test

APPARATUS: Bending test machine, wooden specimens, scale

THEORY:

For a simply supported beam with central loading, maximum bending moment is given by $M = \frac{WL}{4}$.

Bending equation is $\frac{f}{y} = \frac{M}{I} = \frac{E}{R}$.

Where, M – maximum bending moment

f – Bending stress

I – moment of inertia of the section = $\frac{bd^3}{12}$

y – Distance of the outer most fibre from the neutral axis

W – Ultimate load

L – Span of the beam

b – Breadth of the beam

d- Depth of the beam

From bending equation, Theoretical value of ultimate load, $W = \frac{4fZ}{L}$

Where, Z – section modulus = $\frac{I}{y}$

Maximum deflection $\delta = \frac{WL^3}{48EI}$

PROCEDURE:

1. The depth and breadth of the given beam is measured using steel rule.

2. The beam is placed on two wedge supports and midspan position is marked.

3. Load is applied at mispan at regular increments of load and the midspan deflection is noted from deflection dialgauges.

4. A graph is plotted with load on Y axis and deflection on X axis. The slope of this graph gives the value of W/δ.

OBSERVATIONS:

Span of the beam, L = mm

Width of the beam, b = mm

Depth of the beam, d = mm

Moment of inertia, $I = \frac{bd^3}{12}$ = = mm^4

Distance of the outermost fibre from the neutral axis, y = mm

Section modulus, $Z = \frac{I}{y}$ = = mm^3

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum

Least count of deflection dial gauge, LC = mm

Sl. No.	Applied Load, W kgf	Deflection dial reading, n divns	Deflection, δ = n x LC, mm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Ultimate load, W_{max} = _____ kgf

Calculations

From graph, $\frac{W}{\delta}$ = kgf/mm

Modulus of elasticity, $E = \frac{W L^3}{48 \delta I}$ = = _____ kgf/mm^2

= _____ N/mm^2

RESULT:

Date:

Experiment No. 08

VERIFICATION OF CLARK – MAXWELL RECIPROCAL THEOREM

AIM: To verify the law of reciprocal deflection (Clark Maxwell Law)

APPARATUS: Bending test machine, wooden specimens, scale

THEORY: Law of Reciprocal Deflection states that the deflection in a beam element at a point A due the application of load at B is equal to the deflection at B due to the same load at A.

PROCEDURE:

1. Choose a convenient span length and place the specimen on two knife edge supports

2. Mark the quarter span and midspan positions

3. Apply load at midspan and measure deflection at quarter span. Perform this for multiple increments of load.

4. Now, apply load at quarter span and measure deflection at mid span. Perform this for multiple increments of load.

5. Compare the values of deflection obtained in both cases to verify the law.

OBSERVATIONS:

Load at midspan	Deflection at quarter span		Mean
	While increasing	While decreasing	

Load at quarter span	Deflection at mid span		Mean
	While increasing	While decreasing	

RESULT:

Prepared by Kiran S. R., Lecturer, Department of Civil Engineering, Central Polytechnic College Trivandrum